Indian J. Phys. **49**, 385–389 (1975)

Piezoelectric effect in sodium acetylacetonate compound

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(*Received* 2 *January* 1975)

The piezoelectric effect in polarised sodium acetylacetonate compound has been studied. The linearity of the stress dependence of charge was attributed to generation of piezoelectric field in the same direction as the original poling field. This field encourages the domains to be reoriented after releasing the static stress. The peak open circuit voltage (p.o.c.v.) increased with increasing the poling field. The decrease of the p.o.c.v. with raising temperature is due to conduction and the material became unpiezoelectric at 80°C.

1. Introduction

Piezoelectric transducer materials have held a key position as electroacoustic transducers in the sonic and ultrasonic range for some forty years. Until the late 1940 piezoelectric transducers consisted of a handful of piezoelectric single crystals, notably quartz, fochelle salt, torrmaline, ammonium dihydrogen phosphate, etc. In 1947 the first piezoelectric transducer employing polarised ferroelectric barium titanite ceramics appeared since 1957 $BaTiO_3$ has been repaced by lead titanate-zirconate solid solution ceramics offering higher peizoelectricity. Ferroelectrics have electronic and ionic displacements producing nets pontaneous polarization, which can be preferentially oriented by an applied field (Jaffe 1958, Egerton 1955, Shirano 1952, Swaguchi 1953, Ouchi 1965, Tawfik 1969).

The aim of this work is to study the piezoelectric effect of sodium acetylacetonate in order to throw some light on the relation between the piezoelectric effect in this compound and that in ferroelectric materials.

2. Experimental Procedure

Preparation of Sodium Acetylacetonate

Na (ac ac) was prepared from the reaction of the sodium hydroxide with acetylacetone. The principles of the preparation depends on the fact that acetylacetone ($CH_3\text{–}\underset{\underset{O}{\|}}{C}\text{–}CH_2\text{–}\underset{\underset{O}{\|}}{C}\text{–}CH_3$) has very active hydrogen atom in CH_2 group. This hydrogen tends to be replaced by the metal atom to form Na (ac ac). The compound was compressed into rectangular shape 1×1 cm and thickness 4 mm. The pieces were polarised for one hour at room temperature by different fields (50, 100, 150, 200). The polarised samples were then tested after one hour.

Measurement of the Piezoelectric Effect

The effect of temperature on the open circuit voltage was measured by an electronic circuit (Amin & Tawfik 1972). The generated charges were recorded also by galvanometer (VEB K Meotechnik Mellenback/Thur. App. Nr. 94554) connected across the sample. The piezoelectric constant d_{31} of Na (ac ac) compound was calculated from the following equation (Mason 1952).

$$d_{31} = \epsilon/4\pi \cdot \frac{V}{300} \cdot \frac{A}{F.T.},$$

where ϵ is the dielectric constant of the sample at low frequency, V the peak open circuit voltage, F the force dyne and T the thickness in cm

3. Results

Effect of Stress on the Peak Open Circuit Voltage (P.O.C.V.) of Polarised Sodium Acetylacetonate Sample

Samples of sodium acetylacetonate compound were used to study the piezoelectric effect. The samples were differently polarised and then left to about one hour before the experimental run.

Figure 1 shows the relation between the peak open circuit voltage (P.O.C.V.) and the stress in the direction perpendicular to the poling field for the polarized Na (ac.ac) sample.

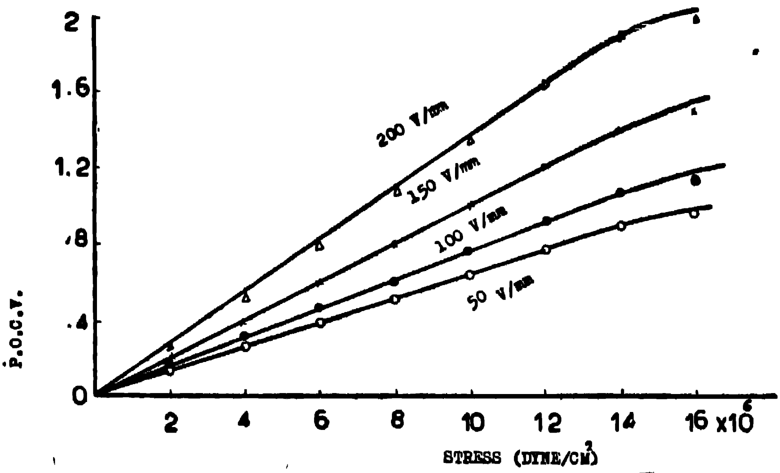

Fig. 1. Stress dependence of the P. O. C. V. of polarized sodium acetylacetonate.

It was noticed that P.O.C.V. increased in nonlinear relationship with the applied stress. The linearity of the generated charge stress curves were observed. Figures 1 and 2 showed also that the slope of P.O.C.V. and charge stress curves increased with increasing the material polarization.

Temperature dependence of piezoelectric response

The P.O.C.V of Na (ac ac) sample was tested at different temperatures. The results given in figures 3 and 4 show that the slope of the curve decreased as the temperature increased and the P.O.C.V. was nearly vanished at about 80°C. The piezoelectric constant d_{31} was determined at different temperature from figure 3. It was found that the piezoelectric constant d_{31} of the sodium acetylacetonate compound decreased with temperature and the material became unpiezoelectric.

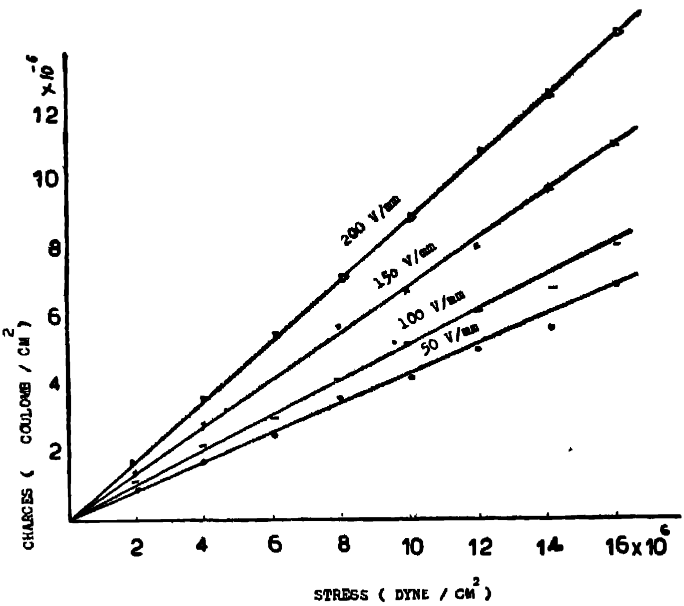

Fig. 2. Charge Stress relation.

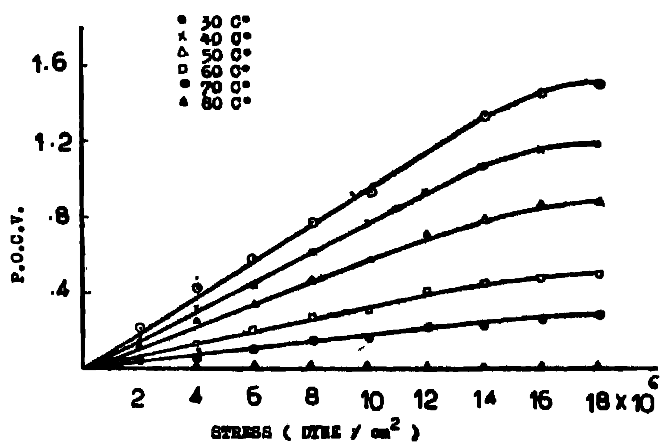

Fig. 3. Effect of temperature on the stress dependence of P. O. C. V.

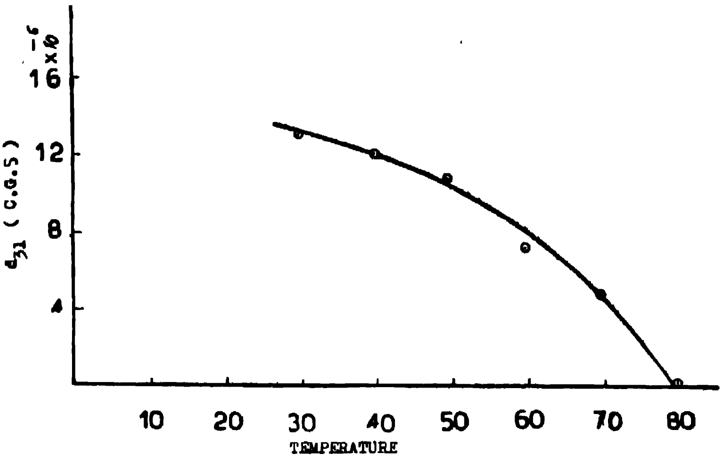

Fig. 4. Effect of temperature on the piezoelectric constant d_{31}

4. Discussion

The Piezoelectric Effect in Na (ac ac) Compound

The linear effect of stress on the P.O.C.V. for Na (ac ac) compound was previously observed in ferroelectric materials at low stress level (Jaffe 1958, Tawfik 1969, Amin 1972). It was noticed that the slope of the P.O.C.V. stress curve increased with increasing the polarization effect in the sample. This might be explained as follows.

It is well known that 180° domains are responsile for piezoelectric effects in the cyrstals. Therefore, by increasing the polarisation of the sample a more proportion of 180° domain was thus reversed during the poling. These domains were maintained entirely after removing the poling field. The strength of polarization thus increased resulting in a higher net polarization at the surface of the sample under an impressing stress. The stress dependence of the generated charges is linear because the charges appearing on the electrode surfaces maintain an electric field in the same direction as the original poling field. This field encourages the domains to be reoriented after releasing the static stress.

The nonlinear behaviour of the stress dependence of the electric field is due to piezoelectrically generated electric field which tend to maintain in the opposite direction to the original poling field and domain reorientation occurs even less readily under open circuit than short circuit conditions. It is obvious that the behaviour of the piezoelectric effect in polarised Na (ac ac) is similar to that of the ferroelectric materials under short circuit condition. The increase of conduction through the sample with raising temperature caused the decrease of the piezoelectric response.

At 80°C the polarization disappeared and the material became unpiezoelectric.

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